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January 31, 2013

The Honorable Jocelyn G. Boyd
Chief Clerk/Administrator
Public Service Commission of South Carolina
101 Executive Center Drive, Suite 100
Columbia, SC 29210

Re: **Docket No. 2009-190-E**

Dear Mrs. Boyd:

Pursuant to the Commission's June 26, 2009 directive in Docket No. 2009-190-E, Progress Energy Carolinas, Inc. submits the attached report summarizing the 2011 program year evaluation, measurement and verification (EM&V) results for its Neighborhood Energy Saver Program. Progress Energy Carolinas, Inc. is currently evaluating the recommendations provided in the EM&V report.

Very Truly Yours,

Timika Shafeek-Horton

Timika Shafeek-Horton
Deputy General Counsel

Attachment
cc: Courtney Edwards

NAVIGANT

2011 EM&V Report for the Neighborhood Energy Saver Program

Prepared for:
Progress Energy Carolinas

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January 28, 2013

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Table of Contents

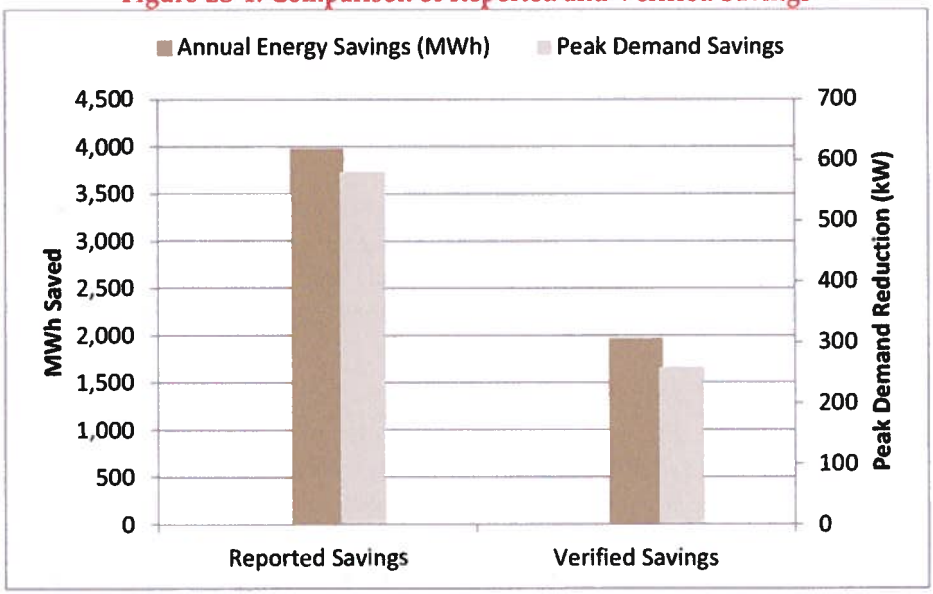
Executive Summary

The Neighborhood Energy Saver (NES) program is part of the portfolio of energy efficiency programs offered to customers by Progress Energy Carolinas (PEC). This report covers evaluation, measurement, and verification (EM&V) activities for NES for Program Year 2011 (PY2011) projects, defined as those customers receiving program services during the 2011 calendar year. The primary purpose of the EM&V assessment was to verify **net annual energy and peak demand impacts** associated with 2011 NES activity. Secondary objectives included:

- Providing updated average per-participant savings
- Providing updated unit savings estimates for each measure[1]
- Evaluating the strengths and weaknesses of current program processes and customer perceptions of the program offering and delivery
- Recommending improvements to program rules and processes that support greater savings, enhanced cost-effectiveness, and improved customer satisfaction

Savings verified through the EM&V assessment (1,964 megawatt-hours [MWh] per year and 259 kilowatts [kW] of peak demand) are roughly 49% of the reported energy savings and 45% of the reported peak demand reductions (Figure ES-1)[2].

Figure ES-1. Comparison of Reported and Verified Savings



[1] Unit savings values are the savings estimated for each measure. These values are in terms of kW and kWh per installed measure. While these values are not used for reporting, they inform the EM&V analysis by providing engineering estimates of savings for each participant.

[2] As the tracking database for PY2011 contains outdated deemed savings values, throughout this document the EM&V team uses the term "reported" to refer to the ex-ante savings values derived by multiplying EM&V verified per-participant savings values from the PY2010 evaluation by the number of NES participants in PY2011.

Program Summary

The NES program generates energy and peak demand reductions by offering free direct installation of energy efficiency measures for residential customers in low-income neighborhoods. Nine unique energy-saving measures address lighting, home heating and air conditioning, and domestic hot water savings. NES installation crews also offer four additional education-only measures, for which PEC claims no energy or demand savings (Table ES-1).

Table ES-1.NES Program Measures

Energy-Saving Measures	Education-Only Measures
1. Screw-in CFL	1. Refrigerator/Freezer Thermometers
2. Refrigerator Coil Brush	2. Wall Switch-Plate Thermometer
3. Low-Flow Showerhead	3. HVAC Filter Change Calendar
4. Low-Flow Faucet Aerator	4. Energy-saving Tips Calendar
5. Set of 12 HVAC Replacement Filters	
6. Infiltration Reductions including HVAC Winterization Kit[a]	
7. Water Heater Temperature Adjustment	
8. Pipe Wrap	
9. Water Heater Blanket[b]	

[a] In the initial program filing, Infiltration Reductions and HVAC Winterization Kit were listed as separate measures. However, since they both serve to reduce air infiltration in the home, the EM&V team treated them as one measure for analysis purposes.

[b] In the initial program filing, water heater tank insulation and water heater pipe insulation were grouped together as one measure. However, in practice they were installed and tracked as separate measures so the EM&V analyzed them as separate measures for clarity.

Source: NES program filing and database

PEC maintains a program tracking database that identifies key characteristics of each site visit, including participant data, measures installed, and estimated energy and peak demand reductions per home based on an assumed ("deemed") savings value for a typical home. Reported program savings for the 4908 customers participating in PY2011 were approximately 4.0 gigawatt-hours (GWh) and 0.58 MW.

Evaluation Methodology

The EM&V assessment of 2011 program activity included both impact and process evaluations. The EM&V approach to the impact analysis in PY2011 is somewhat modified from that used in PY2010 in order to improve the precision of the energy savings estimates. The PY2010 analysis relied primarily on field verification visits and engineering estimates to calculate impacts. The PY2011 impacts analysis began with field verification and engineering estimates and then incorporated a pre- and post-installation billing analysis using late entrants in the program as controls for the early entrants. The two-step process was as follows:

1. **Engineering estimates** of per-participant savings were calculated, based on both *field verified quantities* (items verified as appropriately installed and functioning properly in the field) and *unit savings values* (savings estimates based on secondary literature and on engineering calculations refined with subsequent data collected during the field verification).

2. **Statistically Adjusted Engineering (SAE) Billing Analysis** was conducted using billing data for all program participants in order to remove some of the uncertainty around the engineering estimates of savings. To improve the precision of the billing analysis, the regression model incorporated results of the engineering analysis for each participant. The model specification used late program entrants as *de facto* controls for earlier entrants.

Based on the results of the billing model, the EM&V team calculated a value for the verified net savings, and a subsequent net realization rate. The net realization rate represents the percentage of reported savings verified through the EM&V activities.

The process evaluation used surveys of program participants to assess how well the program is working and to identify opportunities for improvement. Customers answered a series of six process-related questions ranging from energy efficiency awareness to plans for purchasing other energy efficient items to satisfaction with the program. The results fed into a set of recommendations for improving the NES program.

Program Impact Findings

The program-level **net realization rates** for energy and peak demand reductions were 49% and 45%, respectively, resulting in verified net energy savings of approximately 2,000 MWh and verified net peak demand reductions of 0.26 MW for the 2012 program year, shown in Table ES-2.

Table ES-2. PY2011 Net Realization Rates and Verified Net Savings

	Annual Energy Savings (MWh)	Coincident Demand Savings (kW)[a]
Reported Net Savings[b]	3,975[c]	579[c]
Verified Net Savings	1,964	259
Net Realization Rate	49.4%	44.7%[d]

a. "Coincident demand savings" refers to the summer peak here and throughout this report. For winter demand savings, see Appendix B.
b. PEC assumes a NTG ratio of 1.0, meaning net and gross savings are equivalent.
c. After a program year completes, the savings estimate in the tracking database becomes fixed or "locked." Based on the subsequent EM&V assessment, PEC updates that original program-wide savings estimate by applying an EM&V adjustment factor. Results from the EM&V assessment are also incorporated into the subsequent year's program database. However, the PY2010 EM&V report was completed after PY2011 ended, and PEC had not updated the EM&V findings in the PY2011 database. Thus for the purposes of this report, the EM&V team calculated new "reported" energy and peak demand savings using the PY2010 verified per-participant numbers (810 kWh and 0.118 kW) multiplied by 4,908, the number of NES customers served in 2011.
d. Since the billing analysis does not calculate demand savings, the EM&V team applied the billing realization rate from the energy savings engineering estimates (0.604) to the peak demand savings.
Source: Navigant analysis

In-Service Verification Rates

The **measure in-service verification rate** is the ratio of the quantity observed functioning on-site at sampled homes to the measure quantities listed in the database for the sampled homes. In-service verification rates can be different from 1.0 because 1) the measure quantity found is different from that listed in the database, 2) the measure installation quality is below the standard required for full energy savings, or 3) customer behavior is different from the behavior required for energy savings. Generally, in-service rates were lower than 100% (Table ES-3).

Table ES-3. Measure In-service Verification Rates (based on sample homes)

	EM&V Sample		
Measure	[A]	[B]	[C] = [B]/[A]
	EM&V Sample Database Recorded Qty per Participant	EM&V Sample Field Verified Qty per Participant	EM&V Measure In-Service Rate
CFL - Screw-In	9.167	7.458	81.4%
Refrigerator Coil Brush	1.000	0.208	20.8%
Low-Flow Showerhead	1.313	1.000	76.2%
Low-Flow Aerator	2.292	1.667	72.7%
HVAC Filter (Box of 12)	0.840	0.417	49.6%
Infiltration Reductions	0.833	0.833	100.0%
Pipe Wrap	0.417	0.333	80.0%
Water Heater Blanket [a]	0.063	0.000	0.0%
Water Heater Temp Adj. [b]	N/A	0.042	N/A

[a] Only eight water heater blankets were listed in the database for PY2011, and the field sample intentionally oversampled to include three of the eight. None of the water heater blankets were found in place at the sites visited, thus the sample field verified quantity was zero.

[b] Water heater temperature adjustment is not reported in the tracking database, although two of the sample homes (approximately 4%) had hot water temperatures above the 135 degree F action threshold listed on contractor invoices.

Source: NES program database and Navigant analysis

Unit Savings Adjustments

The evaluation team determined the most appropriate **unit savings values** for each measure through a review of savings algorithms and cited sources from the PY2010 evaluation, updated to include measure characteristics observed in the field. Table ES-4 shows the revised energy and peak demand unit savings values. Savings adjustment factors (PEC's assumed per-unit savings divided by Navigant's revised per-unit savings) that are significantly different from 100% for this parameter generally reflect changes in characteristics in the installations or a refined methodology taking into account more field data.

Table ES-4. Annual Energy and Peak Demand Unit Savings and Adjustment Factors

	Unit Savings - Energy			Unit Savings – Peak Demand		
Measure	PY2010 Verified Per-unit Savings (kWh)	PY2011 Revised Per-unit Savings (kWh)	EM&V Energy Savings Adjustment Factor	PY2010 Reported Per-unit Savings (kW)	PY2011 Revised Per-unit Savings (kW)	EM&V Demand Savings Adjustment Factor
CFL - Screw In	52	46	89.4%	0.006	0.005	88.6%
Refrigerator Coil Brush	44	44	100.0%	0.005	0.005	100.0%
Low Flow Showerhead	240	191	79.7%	0.017	0.015	86.4%
Low Flow Aerator	51	40	77.9%	0.006	0.005	76.7%
HVAC Filters (Box of 12)	64	80	123.5%	0.015	0.019	123.5%
Infiltration Reductions	164	44	27.1%	0.060	0.025	41.2%
Pipe Wrap	23	23	100.0%	0.003	0.003	100.0%
Water Heater Blanket	315	153	49%	0.023	0.018	75.8%
Water Heater Temp Adj.	40	62	154%	0.003	0.007	240.2%
Weighted Average[a]			**78%**			**72%**

a. The weighted averages account for the relative impacts on energy and demand savings, respectively, of the nine measures in aggregate compared to PY2010. While this total percentage was not included in any analysis, it represents a rough approximation of the relative change in program-wide unit savings from one EM&V cycle to the next.

Once the in-service rates were calculated and the unit savings review was completed, the evaluation team applied the updated unit savings values to the PY2011 database. Each participant in the tracking database (corresponding to one set of NES measures installed at a unique customer site) was assigned the new verified energy and demand savings values based on the quantities of each measure installed. The EM&V team then leveraged the per-home energy estimates to conduct the billing analysis.

Billing Analysis

After generating engineering savings estimates, the EM&V team estimated four seasonal fixed effects regression models based on billing data provided by PEC. The regression equation included a unique constant term for each participant (the "fixed effect") in each season to implicitly account for participant-specific characteristics that affect energy usage. To prevent selection bias, there was not a separate control group. Rather, participants entering the program later act as a *de facto* control to the earlier participants.

Formally, the regression equation is given by:

$$ADU_{itk} = \alpha_{ik} + \beta_k \cdot EST_{it} + \sum_{1}^{n} \gamma_n \cdot MONTH_{tn} + \epsilon_{itk}$$

Where i indexes the participant, t indexes the billing cycle, and k indexes the season (spring, summer, fall, winter)

ADU_{itk} = Average daily usage (kWh) for participant i in billing cycle t, during season k.

EST_{it} = The participant-specific engineering estimate of savings per day if participant i has installed a major measure in billing cycle t, and a 0 otherwise.

α_{ik} = The participant- and season-specific constant term ("fixed effect"), to be estimated in the regression.

$MONTH_{tn}$ = A dummy variable for the month (and year) for billing cycle t.

β_k, γ_n = Parameters to be estimated in the regression. k iterates the season, and n is for each month-year combination in the data

ϵ_{itk} = The regression error for participant i in billing cycle t, during season k.

Table ES-5 provides annualized savings estimates, 90% confidence intervals (CI), and relative precision from the billing analysis. Navigant estimates average annual savings of 400 kWh. See Appendix A for details of the confidence and precision calculations.

Table ES-1. Savings Estimate, Confidence Interval, and Precision

Estimated Savings (kWh)	90% CI, Lower	90% CI, Upper	Precision at 90% CI
400.2	354.7	445.7	11.4%

Source: Navigant analysis

Recommendations

The EM&V team made a number of recommendations in the PY 2010 EM&V report. PEC program staff are currently implementing some of those recommendations, while others may be implemented in future iterations of the NES program. When polled, customers were generally satisfied with the program. However, EM&V field techs asked customers if there were any changes or improvements to the program that they would like to see. Based on those responses (and on observations during the field visits), the EM&V team recommends:

- Offering non-standard CFL bulb base sizes like candelabra and mini-candelabra
- Taking care to install CFLs in *all* eligible sockets before giving customer bulbs for storage
- Investigating issues where door sweep gasket slides in its track, preventing door closure
- Putting greater emphasis on fewer key educational recommendations to customers in order to improve long-term retention. Recommending specific thermostat and refrigerator temperature set-points and monthly HVAC filter changes have been the most effective educational efforts thus far, based on customer recollection.

1. Introduction

The Neighborhood Energy Saver (NES) program is part of the portfolio of energy efficiency programs offered to customers by Progress Energy Carolinas (PEC). This report covers evaluation, measurement, and verification (EM&V) activities for NES for Program Year 2011 (PY2011) projects, defined as those customers receiving program services during the 2011 calendar year.

EM&V is a term adopted by PEC and refers generally to the assessment and quantification of the **energy and peak demand impacts** of an energy efficiency program. EM&V uses a variety of analytic approaches including on-site verification of installed measures, analysis of customer billing records, and application of engineering and energy simulation models. EM&V also encompasses an evaluation of program processes and customer feedback, typically conducted through participant surveys.

This report is intended for PEC's internal use to support program improvements as well as to support compliance with requirements mandated by the North Carolina Utilities Commission and the Public Service Commission of South Carolina.

1.1 *Objectives of the Evaluation*

The primary purpose of the EM&V assessment was to verify **net annual energy and peak demand impacts** associated with 2011 NES activity. Secondary objectives included:

- Providing updated average per-participant savings
- Providing updated unit savings estimates for each measure[3]
- Evaluating the strengths and weaknesses of current program processes and customer perceptions of the program offering and delivery
- Recommending improvements to program rules and processes that support greater savings, enhanced cost-effectiveness, and improved customer satisfaction

In addition, this report describes strengths and weaknesses of the current program delivery and recommendations for improving total program impacts. The results of this evaluation should allow PEC staff to improve the design of NES to increase benefits delivered while improving cost-effectiveness, thus providing greater value to ratepayers.

1.2 *Reported Program Participation and Savings*

The NES program generates energy and peak demand reductions by offering free direct installation of energy efficiency measures for residential customers in low-income neighborhoods. Nine unique energy-saving measures address lighting, home heating and air conditioning, and domestic hot water savings. NES installation crews also offer four additional education-only measures, for which PEC claims no energy or demand savings (Table 1-1).

[3] Unit savings values are the savings estimated for each measure. These values are in terms of kW and kWh per installed measure. While these values are not used for reporting, they are used to help inform the analysis.

Table 1-1. NES Program Measures

Energy-Saving Measures	Education-Only Measures
1. Screw-in CFL	1. Refrigerator/Freezer Thermometers
2. Refrigerator Coil Brush	2. Wall Switch-Plate Thermometer
3. Low-Flow Showerhead	3. HVAC Filter Change Calendar
4. Low-Flow Faucet Aerator	4. Energy-saving Tips Calendar
5. Set of 12 HVAC Replacement Filters	
6. Infiltration Reductions including HVAC Winterization Kit[a]	
7. Water Heater Temperature Adjustment	
8. Pipe Wrap	
9. Water Heater Blanket[b]	

[a] In the initial program filing, Infiltration Reductions and HVAC Winterization Kit were listed as separate measures. However, as they both serve to reduce air infiltration in the home, they have been analyzed as one measure.
[b] In the initial program filing, water heater tank insulation and water heater pipe insulation were grouped together as one measure. However, in practice they were installed and tracked as separate measures so the EM&V analyzed them as separate measures for clarity.
Source: NES program filing and database

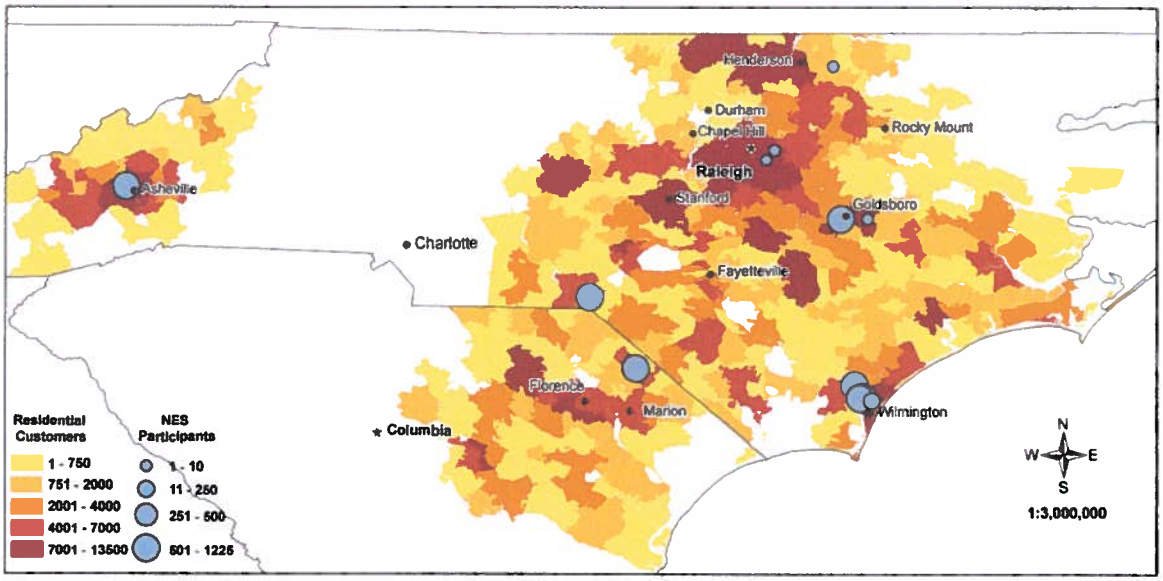
PEC targets its outreach to low-income communities across the service territory by focusing on areas with high concentrations of customers coded as low income. PEC defines a low-income community as one having greater than 50% of the neighborhood under 150% of the federal poverty level. The overall selection process began with internal research, based on PEC's North and South Carolina service territory. Initial neighborhoods were chosen based on PEC's customer demographics data, and then confirmed with data from Equifax. The communities were ordered into a list that rotates geographically throughout PEC's service territory. After the crews finish with one geographic region they move to a different one. PEC attempts to cover each of PEC's regions and rotate coverage roughly in proportion to the concentration of low-income customers.

Once a community has been identified and slated to receive installs, the program manager contacts both official and informal community leaders and community centers to identify target neighborhoods and arranges publicity and a local "kickoff" event in cooperation with local organizations as an economical means of attracting potential program participants. Targeting outreach at this level using community networks appears to be effective; residents in the targeted communities are informed about the program in a familiar environment and made comfortable about the implementation contractors who will be working in the neighborhoods. Reassurance about the program and contractor legitimacy is an important factor in recruiting participants. NES kickoff planners employ translators in communities with high Hispanic populations, and also provide child care during the events.

PEC maintains a program tracking database that identifies key characteristics of each site visit, including participant data, measures installed, and estimated energy and peak demand reductions per home based on an assumed ("deemed") savings value for a typical home. During 2011, the program covered neighborhoods in five cities, including Asheville, Goldsboro, Hamlet, and Wilmington in North Carolina, as well as Dillon, South Carolina. The location and relative numbers of participants during 2011 are shown in Figure 1-1. The size of the solid circles in the figure represents the relative number of program participants by zip code, while the shaded areas represent the relative density of PEC

residential customers, with darker browns representing higher population density and lighter yellows lower.

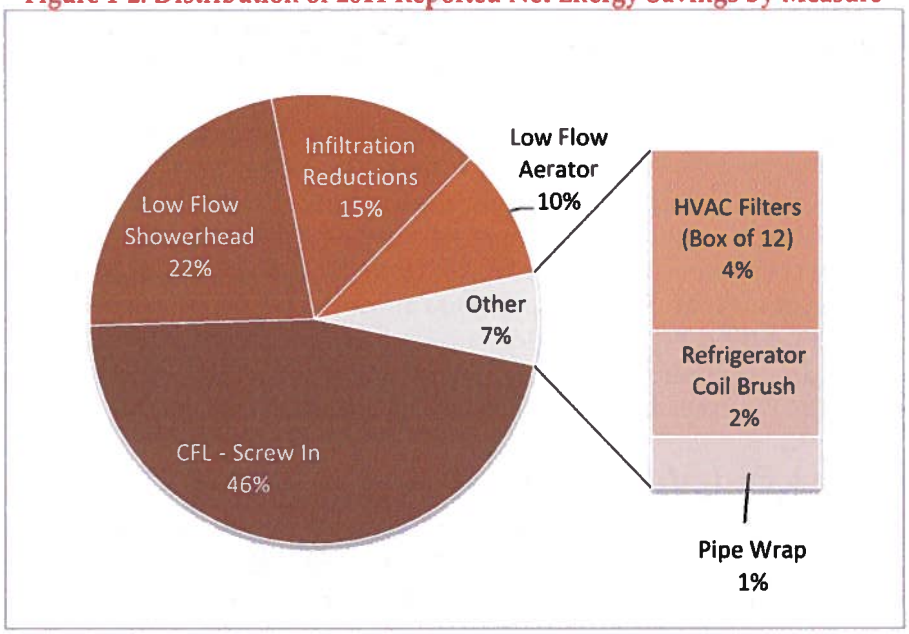
Figure 1-1. PY2011 NES Participant Map



Source: Navigant analysis of NES tracking database, PEC residential demographics database, U.S. census zip code shapes

According to the NES database, the program served 4,908 participants in 2011. PEC has adopted deemed savings values on a per-participant basis according to the verified findings from the PY2010 EM&V effort. Given the verified savings values of 810 kWh per year and peak demand reductions of 0.14 kW for each participant, reported savings from PY2011 participants were 4.0 GWh, with a peak demand reduction of 0.58 MW. Figure 1-2 below shows the assumed share of energy savings by measure, with CFLs, low-flow showerheads, and infiltration reductions dominating the savings. The assumed share of peak demand reductions by measure was roughly the same as it was for total energy savings. Detailed engineering savings estimates by measure are provided in Appendix B.

Figure 1-2. Distribution of 2011 Reported Net Energy Savings by Measure



Source: Navigant analysis of PEC tracking database

2. Evaluation Methods

The steps used in evaluating NES for PY2011 are similar to those used successfully by the EM&V team in evaluating other Progress Energy and out-of-state utility energy efficiency programs. The program database provided a starting point for understanding the mix of measures installed. Details of the evaluation plan and analysis were informed by discussions with program and EM&V staff as well as findings from the previous year's evaluation (PY2010). The team collected field data through on-site visits and surveys to verify tracking data and to provide inputs for the engineering algorithms which fed into the impact analysis. Finally, in-field interview data was synthesized into process findings and total program impacts were calculated using the results of the Statistically Adjusted Engineering Billing Analysis (SAE). The evaluation process followed four discrete steps, outlined below.

2.1 *Step 1: Evaluation Planning*

The PY2011 evaluation began with informal conversations with PEC evaluation and program staff after filing of the PY2010 report in June, 2012. As this was the second year in the evaluation cycle, the EM&V team already had much of the program documentation, so the only data sources reviewed were the following:

- Program tracking database (the E2DR Datastore™ database provided to PEC by V-TECH, Inc.)
- Honeywell's installer invoices for the verification sample

Additionally, based on feedback from the PEC evaluation staff, the EM&V team conducted a billing analysis that incorporates monthly billing data and leveraged engineering estimates from the field verification work.

2.2 *Step 2: Data Collection*

The on-site sample was stratified by home type and region, with the objective of getting a representative sample of the population and 90/10 confidence and precision at the program level.[4] The on-site verification sample is shown in Table 2-1. Quantities in each stratum are roughly proportional to those in the overall population. No sites were visited in the Northern region because only a negligible number of installations took place there. See Appendices B and D for details on field data collection, including onsite survey forms.

[4] Actual precision could not be determined with certainty until after the verification data were collected since the variability of the data are a significant determinant of the level of precision. In the end, the sample size was sufficient for a relative precision of +/- 9% at a 90% confidence interval on the measure installation characteristics (see Appendix C).

Table 2-1. On-Site Verification Sample

PEC Region	Single-Family	Multi-Family	Manufactured Housing	Total
North	0[a]	0[a]	0[a]	0
South	9	4	4	17
East	14	4	2	20
West	5	1[b]	5	11
Total	28	9	11	**48**

[a] PY2011 population size was too small to warrant sampling of manufactured homes in this region.
[b] Sample size called for two western/multi-family, but only one customer responded.

2.3 *Step 3: Process Evaluation*

The Year Two process evaluation is based largely on data collected during the field verification survey. Each participant was asked six process-related questions, relating to energy efficiency awareness, satisfaction with the program, and suggestions for improving the offerings. The evaluation team analyzed survey results to determine what portions of the program are working well, and where PEC might be able to make improvements. See Appendix D for a summary of process-related findings.

2.4 *Step 4: Impact Analysis*

The EM&V team's approach to the impact analysis in PY2011 is somewhat modified from PY2010, which relied primarily on field verification visits and engineering estimates to calculate impacts. Field verification of measure quantities is relatively straightforward and accurate; however, verification of measure savings typically required costly in-field data logging and measurements, such as pre- and post-installation blower door testing of air infiltration rates to assess the savings resulting from weatherization measures. Due to the uncertainty of the deemed savings values and the expense of in-field verification, for the PY2011 impacts analysis Navigant used an EM&V approach that started with field verification and engineering estimates and then incorporated a pre- and post-installation billing analysis which used late entrants in the program as controls for the early entrants. This is a common methodology used in M&V work to leverage field work and engineering estimates to improve the final savings estimates. The two-step process was as follows:

1. **Engineering Estimates** of per-participant savings were calculated, based on both *field verified quantities* (items verified as appropriately installed and functioning properly in the field) and *unit savings values* (savings estimates based on secondary literature and on engineering calculations refined with subsequent data collected during the field verification).

2. **Statistically Adjusted Engineering (SAE) Billing Analysis** was conducted using billing data for all program participants in order to remove some of the uncertainty around the engineering estimates of savings. To improve the precision of the billing analysis, the regression model incorporated results of the engineering analysis for each participant. The model specification uses late program entrants as *de facto* controls for earlier entrants (See Section 2.4.2 and Appendix A for a discussion of the billing analysis methodology).

The sections below outline the PY2011 impacts methodology in greater detail.

2.4.1 Engineering Estimation

The engineering analysis consisted of three parts:

1. deriving **in-service rates** from on-site visits,
2. updating **measure unit savings** based on engineering review and secondary literature, and
3. estimating **energy and demand savings** (using steps 1 and 2) for each customer that participated in PY2011. Appendix B provides a more in-depth look at the analysis process for each measure.

1. *Derive Measure-Level In-Service Rates*

In order to leverage the program tracking database which tracks the measure quantities installed, the results of the field data collection activity were compared with PEC's database recorded installations for *quantitative* differences and checked against the measure installation protocols for *qualitative* differences. The findings were aggregated for each measure in order to determine the measure in-service rate. The calculation of the in-service rate (ISR) relies on the **In-Service Quantity**, or the quantity found to be in working order and being used properly to ensure full energy savings, and the per-measure **Database Recorded Quantity** for sampled participants. A description of each of the terms used in calculating the final field in-service rate is as follows:

1. **Database Recorded Quantity** (from the sample) – the average quantity of each measure installed per home and recorded in the tracking database for the 48 homes from the EM&V sample.

2. **In-Service Quantity** – the average quantity of each measure counted during the EM&V field study. This includes only measures that were physically counted *and* in working order and being used properly by the client for energy savings. For example, if one refrigerator coil brush was counted but the customer reported never having used it, the In-Service Quantity of the refrigerator coil brush for that home was zero.

3. **In-Service Rate (ISR)** – the in-service quantity (2) divided by the database recorded quantity for the sample (1) gives the in-service rate.

2. *Update Unit Savings*

As this was the second year of the evaluation, the general process of updating unit savings values was somewhat less involved than the first year. However, some energy savings algorithms were updated with field collected data and a literature review was conducted for certain measures to get updated **unit energy savings** and **unit peak demand reductions**.[5] Where possible, peak demand savings use coincidence factors based on the Building America Benchmark analysis spreadsheets for existing homes.[6] Appendix B provides more detail on the process for updating the unit savings values for each measure.

[5] "Unit energy savings" refers to the assumed savings for installation or performance of one measure (e.g., one compact fluorescent bulb or one low-flow showerhead) at a single participant's residence.
[6] Building America Benchmark Analysis Spreadsheets [accessed November, 2011]: http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html

3. *Apply Unit Savings and Measure In-service Rates to PY2011 Database*

Once the in-service rates and unit savings review was completed, the evaluation team applied the updated **unit savings** values to the PY2011 database. Each participant in the tracking database (corresponding to one set of NES measures installed at a unique customer site) was assigned the new verified energy and demand savings values using the following equation:

$$EST_{ann} = \sum_{i=1}^{n} Q_{db,i} \times ISR_i \times E_{sav,i}$$

Where:

- EST_{ann} is the annual energy or demand savings estimate for one customer in the database
- $Q_{db,i}$ is the installed quantity for measure *i* reported in the tracking database
- ISR_i is the in-service rate for measure *i* based on field verification work
- $E_{sav,i}$ is the unit energy or demand savings for measure *i*
- *n* is the number of different measures installed at the home in question

Free ridership was assessed at a high level via a brief on-site survey of participants, inquiring whether they would have purchased any of the measures if the NES were not available to them. This analysis supported PEC's historical use of a net-to-gross (NTG) value of 1.0. However, the billing model estimates net savings. If there were some free ridership with this program, the billing model would properly address the issue because it uses a pipeline control of late-entering customers who behave similarly to the early entrants.

2.4.2 Billing Analysis

Calculate Statistically Adjusted Engineering (SAE) Billing Model

After generating engineering savings estimates, the EM&V team estimated four seasonal fixed effects regression models based on billing data provided by PEC. The regression equation included a unique constant term for each participant (the "fixed effect") in each season to implicitly account for participant-specific characteristics that affect energy usage. To prevent selection bias, there was not a separate control group. Rather, participants entering the program later act as a *de facto* control to the earlier participants.

Often monthly billing regression models are specified with heating degree days and cooling degree days as regressors to account for weather effects. After some initial test models however, the EM&V team chose a model specification that uses monthly dummy variables as regressors and does not include weather-specific variables like degree-days. This model specification accounts for differences in households that are both constant over time (such as the square footage of the residence, number of occupants, and indoor temperature preferences), and those that may vary temporally (holiday behavior differences, economic recession impacts, etc.).

According to the model specification, average daily usage (kWh) is a function of the month and year of the billing cycle and the participant-specific engineering estimate of savings. This allows usage to vary on a monthly basis and program savings to vary on a seasonal basis. Because the regression includes the

participant-specific engineering estimates of savings, the regression equation is called a Statistically Adjusted Engineering (SAE) model. Formally, the regression equation is given by:

$$ADU_{itk} = \alpha_{ik} + \beta_k \cdot EST_{it} + \sum_{1}^{n} \gamma_n \cdot MONTH_{tn} + \epsilon_{itk}$$

Where i indexes the participant, t indexes the billing cycle, and k indexes the season (spring, summer, fall, winter)

ADU_{itk} = Average daily usage (kWh) for participant i in billing cycle t, during season k.

EST_{it} = The participant-specific engineering estimate of savings per day if participant i has installed a major measure in billing cycle t, and a 0 otherwise.

α_{ik} = The participant- and season-specific constant term ("fixed effect"), to be estimated in the regression.

$MONTH_{tn}$ = A dummy variable for the month (and year) for billing cycle t.

β_k, γ_n = Parameters to be estimated in the regression. k iterates the season, and n is for each month-year combination in the data

ϵ_{itk} = The regression error for participant i in billing cycle t, during season k. Standard errors are clustered to account for heteroskedasticity and autocorrelation[7] at the participant/season level.

Savings, given in average daily kWh, are calculated using only regression terms that involve the savings estimate variable (EST), as follows:

$$Average\ Verified\ Savings = \sum_{k=1}^{4} \frac{-\overline{EST_k} * \beta_k}{4}$$

$\overline{EST_k}$ is the average daily engineering estimate of savings for participants in PY2011 during season k.

The average savings values from the SAE analysis were multiplied by the number of participants (4,908) in PY2011and multiplied by 365 days to calculate net energy savings. **Realization rates** were then calculated for the program as a whole as the ratio of verified savings to reported savings. Alternatively, since PEC reports the same savings for each participant regardless of the installed measures, the same realization rate can be calculated simply dividing the average verified savings estimate by PEC's reported value of 810 kWh/yr.

[7] *Autocorrelation* describes the correlation between values of the process at different times, as a function of the two times or of the time difference. *Heteroskedasticity* describes the situation where variance changes over time.

3. Program Impacts

PEC's program tracking database provided program-level savings values for energy and peak demand ("**reported net savings**") based on program participation data and assumed per-participant savings, or "**deemed savings**", values.[8] As discussed in Section 2.4, the EM&V team calculated savings using a pre- and post-installation billing analysis that incorporated engineering estimates of savings for each participant. The result was the **verified net savings** for the program as a whole.[9]

Table 3-1 compares the **verified net savings** to the **reported net savings** for Program Year (PY) 2011. The relationship between these two values is the "net realization rate," shown here to be 49.4% for energy savings and 44.7% for peak demand reductions.[10]

Table 3-1. 2011 Annual Energy and Demand Reductions

	Annual Energy Savings (MWh)	Coincident Demand Savings (kW)[a]
Reported Net Savings	3,975[b]	579[b]
Verified Net Savings	1,964	259
Net Realization Rate	49.4%	44.7%[c]

a. "Coincident demand savings" refers to the summer peak here and throughout this report. For winter demand savings, see Appendix B.
b. After a program year completes, the savings estimate in the tracking database becomes fixed or "locked." Based on the subsequent EM&V assessment, PEC updates that original program-wide savings estimate by applying an EM&V adjustment factor. Results from the EM&V assessment are also incorporated into the subsequent year's program database. However, the PY2010 EM&V report was completed after PY2011 ended, and PEC had not updated the EM&V findings in the PY2011 database. Thus for the purposes of this report, the EM&V team calculated new "reported" energy and peak demand savings using the PY2010 verified per-participant numbers (810 kWh and 0.118 kW) multiplied by 4,908, the number of NES customers served in 2011.
c. Since the billing analysis does not calculate demand savings, the EM&V team applied the billing realization rate from the energy savings engineering estimates (0.604) to the peak demand savings.
Source: Navigant analysis

[8] PEC assumes a 1.0 net-to-gross ratio for the NES program, thus both net and gross savings are equal.
[9] As stated in section 2.4.1, the billing model as specified inherently estimates "net" savings. While some participants may have taken energy conserving actions or purchased high efficiency equipment anyway, the use of a late-entrant or "pipeline" control group ensures that the control group can be expected to exhibit the same degree of energy conserving behavior and purchases. Thus, the differences in consumption due to participation in the program are the net impact of the program, and no "net-to-gross" adjustment is necessary.
[10] As is often the case with SAE analyses, the billing-based results came in lower than the pure engineering estimates. This is due primarily to the uncertainty surrounding unit savings values when conducting a verification study that does not involve any direct metering.

The remainder of this chapter presents the detailed impact findings broken down into the component parts:

1. **Engineering Savings Estimates**
    a. **Measure in-service rate:** ratio of the quantities of equipment and measures verified on-site versus the quantities recorded in the program database
    b. **Savings adjustment factor:** ratio of updated unit savings values to the deemed savings values used in the program tracking database
    c. **Engineering estimated savings:** net reductions in energy and consumption and peak demand verified through EM&V activities
2. **SAE Billing Model:** Regression model used to estimate program energy savings given customer billing data and engineering estimates of energy savings
3. **Net realization rate:** ratio of verified net savings to reported net savings[11]

3.1 Engineering Savings Estimates

The PY2010 EM&V impacts analysis was based on verification site visits which informed engineering estimates. While this is a sound methodology, there is still uncertainty associated with the final results. The measure quantities calculated from onsite verification visits are generally very reliable since the measures are physically counted. However, the unit savings estimates contain certain untested assumptions and even a well-researched measure savings estimate may be biased. When billing data is available, engineering estimates can be used to inform a Statistically Adjusted Engineering (SAE) billing model that can yield much more accurate results than a simple engineering estimate. The PY2011 EM&V work includes an SAE billing model, hence the presentation of engineering savings estimates is focused primarily on generating inputs to the model. For consistency and comparison with PY2010, tables of measure-level impacts estimates can be found in Appendix B.

3.1.1 Measure In-Service Verification Rates

The **measure in-service verification rate** is the ratio of the measure quantity observed functioning on-site at sampled homes to the quantity listed in the database for the sampled homes. There are several reasons the measure in-service verification rate could be different from 100%:

1. Measure quantity found is different from that listed in the database.
2. Measure installation quality is below the standard required for full energy savings.
3. Customer behavior is different from the behavior required for energy savings.

Generally, in-service rates were lower than 100% (see Table 3-2).

[11] PEC does not report savings at the measure level, so net realization rates for the individual measures were calculated as the ratio of verified savings to the per-home measure savings assumed by PEC before the program began.

Table 3-2. Measure In-service Verification Rates (based on sample homes)

Measure	EM&V Sample [A] EM&V Sample Database Recorded Qty per Participant	EM&V Sample [B] EM&V Sample Field Verified Qty per Participant	[C] = [B]/[A] EM&V Measure In-Service Rate
CFL - Screw-In	9.167	7.458	81.4%
Refrigerator Coil Brush	1.000	0.208	20.8%
Low-Flow Showerhead	1.313	1.000	76.2%
Low-Flow Aerator	2.292	1.667	72.7%
HVAC Filter (Box of 12)	0.840	0.417	49.6%
Infiltration Reductions	0.833	0.833	100.0%
Pipe Wrap	0.417	0.333	80.0%
Water Heater Blanket[a]	0.063	0.000	0.0%
Water Heater Temp Adj.[b]	N/A	0.042	N/A

[a] Only eight water heater blankets were listed in the database for PY2011, and the field sample intentionally included three of the eight. None of the water heater blankets were found in place, thus the sample field verified quantity was zero.

[b] Water heater temperature adjustment is not reported in the tracking database, although two of the sample homes (approximately 4%) had hot water temperatures above the 135 degree F action threshold listed on contractor invoices.

Source: NES program database and Navigant analysis

3.1.2 Unit Savings Adjustments[12]

As noted above, the evaluation team determined the most appropriate **unit savings values** for each measure through a review of PEC's initial deemed saving estimates, updated to include measure characteristics observed in the field.

The team then assigned measure-specific **savings adjustment factors** by comparing these updated unit savings values with the PY2010 verified savings values for each measure. Expressed as a percentage of deemed savings values, adjustment factors illustrate the direction and magnitude of the EM&V changes to unit savings values. A value of 100% indicates that the evaluation resulted in no change to the unit savings value used by PEC. Values less than 100% indicate a reduction in unit savings, and values in excess of 100% indicate an increase in unit savings. The deemed savings values and the verified (updated) unit savings values for PY2011 are presented in Table 3-3 for both energy savings and demand reductions.

[12] For the PY2010 analysis, the EM&V team defined a per-measure *field verification rate* that compared EM&V quantities with those assumed by PEC prior to the program start. Since the PY2011 evaluation includes an SAE analysis, however, the idea of a per-measure "field verification rate" against assumed quantities is not necessary. Instead, the analysis leverages in-service rates from the field work applied to the database for PY2011 to get a *per-participant* average savings. The resulting per-participant value is the same as it would have been if calculated using the field verification rate, but the process is simplified.

Table 3-3. Annual Energy and Peak Demand Unit Savings and Adjustment Factors

	Unit Savings - Energy			Unit Savings – Peak Demand		
Measure	PY2010 Verified Per-unit Savings (kWh)	PY2011 Revised Per-unit Savings (kWh)	EM&V Energy Savings Adjustment Factor	PY2010 Verified Per-unit Savings (kW)	PY2011 Revised Per-unit Savings (kW)	EM&V Demand Savings Adjustment Factor
CFL - Screw In	52	46	89.4%	0.006	0.005	88.6%
Refrigerator Coil Brush	44	44	100.0%	0.005	0.005	100.0%
Low Flow Showerhead	240	191	79.7%	0.017	0.015	86.4%
Low Flow Aerator	51	40	77.9%	0.006	0.005	76.7%
HVAC Filters (Box of 12)	64	80	123.5%	0.015	0.019	123.5%
Infiltration Reductions	164	44	27.1%	0.060	0.025	41.2%
Pipe Wrap	23	23	100.0%	0.003	0.003	100.0%
Water Heater Blanket	315	153	49%	0.023	0.018	75.8%
Water Heater Temp Adj.	40	62	154%	0.003	0.007	240.2%
Weighted Average[a]			**78%**			**72%**

a. The weighted averages account for the relative impacts on energy and demand savings, respectively, of the nine measures in aggregate compared to PY2010. While this total percentage was not included in any analysis, it represents a rough approximation of the relative change in program-wide unit savings from one EM&V cycle to the next.

For most measures, there is a large disparity between the PY2010 **verified savings** and PY2011 **verified (revised) savings**. Savings adjustments reflect both changes in installation characteristics since PY2010 and further revisions to the assumptions in the original deemed savings estimates. Specifically, the primary reasons for the discrepancies in unit savings are that the EM&V assessment:

1. **Revised inputs to engineering-based energy-saving algorithms.** For some measures (CFLs, low-flow showerheads, low-flow faucet aerators, water temperature adjustment, HVAC filters) the evaluation team collected field data to feed energy and demand savings algorithms. In some cases, these caused changes in unit savings values. For instance, hot water measure savings from PY2010 had been based on assumed cold-water temperatures from the literature. During PY2011 field data collection, cold water temperatures were taken for all sampled homes, and adjusted for seasonal variation. These temperatures were higher than the literature-cited values, causing a reduction in savings for most hot water measures.

2. **Adjusted PY2010 values based on differing installation characteristics/protocols for NES.** Sometimes installation characteristics simply change year to year. CFLs of different wattages are installed in different mixture of rooms. Savings from water heater temperature adjustments depend significantly on the pre- and post-adjustment water temperatures. The average length of time between customer-reported HVAC filter changes can vary significantly year-to-year. These sorts of changes are largely the result of natural and/or regional variation and will always cause changes year-to-year.

3.1.3 PY2011 Engineering Savings Estimates

The PY2011 impact evaluation calculates estimated savings for each customer in the program database (for use in the billing model) based on multiplying installed measure quantities by in-service rates and database quantities, as outlined in section 2.4.1. For illustration, the process is shown in Table 3-4 and Table 3-5 as calculated in aggregate, which results in the same final average engineering estimate of energy savings as when the calculations are done on a per-participant basis.

Table 3-4. Summary of Per-measure Database Reported Quantities

	PY2011 Population Database Recorded Quantities		
	[A]	[B]	[C] = [A]/[B]
Measure	Database Quantity	Total # of Participants	Database Average Qty per Participant
CFL - Screw In	44,911	4908	9.151
Refrigerator Coil Brush	4,913	4908	1.001
Low Flow Showerhead	5,789	4908	1.180
Low Flow Aerator	10,591	4908	2.158
HVAC Filter (Box of 12)	3,902	4908	0.795
Infiltration Reductions	3,902	4908	0.795
Pipe Wrap	1,399	4908	0.285
Water Heater Blanket	8	4908	0.002
Water Heater Temp Adj.	N/A[a]	4908	0.042[a]

a. Water heater temperature adjustments are not tracked in the database, but do appear on installer invoices. For the sake of consistency, the average per-participant quantity of the sample was applied to the PY2011 population.

Source: Navigant analysis, PEC tracking database

The database average quantity per participant is the starting point for calculation of average per-participant savings. The application of in-service rates from the field verification work leverages information collected about a random sample to infer the relative efficacy of the measure installation (and utilization) process. For instance, the EM&V field staff found that in many houses, customers received a certain quantity of CFL bulbs, but ended up putting some of them away in the closet to bring out for future use. Savings cannot be counted for those bulbs in storage as it is likely they will replace CFLs eventually, if used at all. This means the effective average quantity of CFLs per household is not the database average of 9.151 or the sample verified quantity of 7.46, but rather 7.45 (PY2011 database average quantity times the in-service rate for CFLs). Table 3-5 shows the mean per-participant savings by measure.

Table 3-5 - Summary of Per-Participant Measure Level Engineering Energy Savings Estimates

	EM&V Engineering Estimate			
Measure	[A] PY2011 Database Recorded Average Qty per Participant	[B] EM&V Revised Per-unit Savings (kWh)	[C] EM&V Measure In-service Rate	[D] = [A]x[B]x[C] EM&V Engineering Energy Savings Estimate (kWh)
CFL - Screw In	9.151	46.3	0.814	344.4
Refrigerator Coil Brush	1.001	43.5	0.208	9.1
Low Flow Showerhead	1.180	191.1	0.762	171.8
Low Flow Aerator	2.158	39.7	0.727	62.4
HVAC Filter (Box of 12)	0.795	79.7	0.496	31.4
Infiltration Reductions	0.795	44.4	1.001	35.3
Pipe Wrap	0.285	23.1	0.800	5.3
Water Heater Blanket	0.002	0.0	0.000	0.0
Water Heater Temp Adj.	0.042	61.7	1.000	2.5
				662.2[a]

a. It should be noted that this initial per-participant engineering energy savings estimate of 662 kWh/yr is significantly lower than the PY2010 verified savings value of 810 kWh/yr. Appendix B discusses the differences in engineering savings estimates in more detail. The billing model provides us with an even better estimate using customer billing data which revises the estimate further.

Source: PEC tracking database, Navigant analysis

3.2 *Statistically Adjusted Engineering (SAE) Billing Model*

After calculating engineering estimates for each participant separately using the adjusted measure quantities for each customer and the unit savings values, the estimates were joined with the billing data before normalizing by the number of days in each billing cycle to create the final billing dataset.

To review, the SAE regression equation is given by:

$$ADU_{itk} = \alpha_{ik} + \beta_k \cdot EST_{it} + \sum_{1}^{n} \gamma_n \cdot MONTH_{tn} + \epsilon_{itk}$$

Where i indexes the participant, t indexes the billing cycle, and k indexes the season (spring, summer, fall, winter)

ADU_{itk} = Average daily usage (kWh) for participant i in billing cycle t, during season k.

EST_{it} = The participant-specific engineering estimate of savings per day if participant i has installed a major measure in billing cycle t, and a 0 otherwise.

α_{ik} = The participant- and season-specific constant term ("fixed effect"), to be estimated in the regression.

$MONTH_{tn}$ = A dummy variable for the month (and year) for billing cycle t.

β_k, γ_n = Parameters to be estimated in the regression. k iterates the season, and n is for each month-year combination in the data

ϵ_{itk} = The regression error for participant i in billing cycle t, during season k.

The key parameter estimates for the SAE model appear below in Table 3-6. A t-statistic greater than 1.65 in absolute value indicates the parameter is statistically significantly different from zero at the 90% confidence level. All coefficients for estimated savings from the model are statistically significant at the 90% level except the summer. This is likely because a large portion of savings are attributable to CFLs and hot water measures (which have greater savings in the wintertime) and because electricity consumption in general is so high in the summertime—essentially it becomes difficult for the model to discern small signal during a season with greater noise in the consumption data. It is also worth noting that all coefficients have the expected sign (that is, they are less than zero), indicating energy savings.

Table 3-6 - Regression Model Parameter Estimates

Season	Estimate (β_k)	Standard Error[1]	T-Statistic
Winter	-1.4990	0.19697	-7.6101
Spring	-0.6040	0.12557	-4.8101
Summer	-0.1216	0.145124	-0.8377
Fall	-0.2316	0.12747	-1.8168

a. Standard errors calculated using the clustered standard error methodology
Source: Navigant analysis

It is worth noting that the model indicates that greatest savings are found in the wintertime and the smallest savings are found in the summertime (by comparing the β_k's). As stated before, this is largely due to CFLs and hot water measures dominating the savings mix. Shorter days in the wintertime cause an increase in lighting usage (and thus savings), while the hotter summer days bring warmer mains temperatures (and often a desire for cooler showers), so the summer energy usage and savings are lower for hot water measures as well.

Annualized savings estimates, 90% confidence intervals (CI), and relative precision from the billing analysis are given in Table 3-7. Navigant estimates average annual savings of 400.2 kWh. See Appendix A for details of the confidence and precision calculations.

Table 3-7. Average Savings Estimate, Confidence Interval, and Precision

Estimated Savings (kWh)	90% CI, Lower	90% CI, Upper	Precision at 90% CI
400.2	354.7	445.7	11.4%

Source: Navigant analysis

Due to the fact that the billing model includes all but 3% of PY2011 customers, the estimated savings for the PY2011 population included in the sample was nearly identical to that of the PY2011 population as a whole (i.e. within 0.1%), so the model estimated savings are the same as the PY2011 adjusted annual energy savings.

3.3 *Verified Net Savings and Net Realization Rates*

The EM&V impacts assessment verified net annual energy savings as 400.2 kWh per participant, or approximately 49% of the 810 kWh per participant assumed by PEC. Net realization rates for peak demand savings were comparable at 45%.

3.3.1 Energy (MWh) Savings

For Program Year 2011, the NES program's 4,908 participants saved about 2.0 GWh, or approximately 2 GWh less than the PEC reported values (Table 3-8).

Table 3-8. Comparison of Reported to Verified Energy Savings at the Program Level

	[A] Net Savings per Participant (kWh)	[B] PY2011 Participation (# of Participants)	[C]=[A]x[B] Net Savings (MWh)
Verified	400.2	4,908	1,964
PEC Reported	810	4,908	3,975
Change in Net Savings			-2,011

Source: PEC tracking database, Navigant analysis

Although the billing estimate for per-participant savings comes in significantly lower than the engineering estimate of 662 kWh per participant, there is still value in looking at the relative contributions of measures according to the engineering estimate. Appendix B presents the findings of the EM&V field work in greater detail.

3.3.2 Peak Demand Reductions

Given that the SAE analysis uses monthly energy consumption for participants to estimate savings, peak demand reductions cannot be estimated directly. Instead, engineering estimates for peak demand savings were adjusted by the same realization rate (i.e. 400.2 ÷ 662.2 = 60.4%) as the energy savings to yield verified per-participant and demand savings. The EM&V assessment verified net peak demand savings as 0.0527 kWh per participant, or approximately 44.7% of the 0.118 kW savings per participant assumed by PEC.

For Program Year 2011, the NES program's 4,908 participants reduced peak demand by nearly 0.259 MW, or approximately 0.3 MW less than the PEC reported values (Table 3-9).

Table 3-9. Comparison of Reported to Verified Peak Demand Savings at the Program Level

	[A] Net Savings per Participant (kW)	[B] PY2011 Participation (# of Participants)	[C]=[A]x[B]/1000 Net Savings (MW)
Verified	0.0527	4,908	0.259
PEC Reported	0.118	4,908	0.579
Change in Net Savings			-0.320

Source: PEC tracking database, Navigant analysis

For more detail on measure-level adjustments and for winter peak reductions see Appendix B.

4. Conclusions and Recommendations

Broad conclusions from the EM&V assessment are provided below, followed by recommendations for potential changes in program design and delivery that can improve savings and tracking.

4.1 *Conclusions*

Based on this initial EM&V assessment, the NES program is running well in its second year, with strong participation, albeit at somewhat lower than estimated savings. EM&V findings reduced the reported savings by roughly 49.4% for energy savings and 44.7% for peak demand savings primarily due to the introduction of the billing model which was able to account for such unknowns as customer behavior and pre-installation conditions. Navigant anticipates that future evaluations will find realization rates closer to 100%.

Generally quantities found in the field matched what was recorded in the database, with some exceptions for CFLs kept in storage, and some showerheads replaced based on customer preference. The low in-service rates for certain measures were due mainly to absence of customer behavior change in order to take advantage of savings. NES generally has good data tracking and quality control, both of which are necessary for the long-term success of the program.

PEC concluded a successful second year administering NES, covering a wide geographic area and getting strong participation in several regions across the service territory. The 4,908 participants in PY2011 exceeded the annual program participation goal of 4,500. Participation rates continue to remain high, with approximately 85% participation in PY2011. The high participation rates are driven by an effective delivery mechanism, good marketing, and participant satisfaction with the program leading to word-of-mouth advertising.

4.2 *Recommendations*

The EM&V team made a number of recommendations in the PY 2010 EM&V report. PEC program staff are currently implementing some of those recommendations, while others may be implemented in future iterations of the NES program. In the current round EM&V findings (PY2011), there are not as many new recommendations to be made. When polled, customers were generally satisfied with the program. However, EM&V field technicians asked customers if there were any changes or improvements to the program that they would like to see. Based on those responses (and observations during the field visits), the EM&V team recommends:

- Offering non-standard CFL bulb base sizes like candelabra and mini-candelabra
- Taking care to install CFLs in *all* eligible sockets before giving customer bulbs for storage
- Investigating issues where door sweep gasket slides in its track, preventing door closure
- Putting greater emphasis on fewer key educational recommendations to customers in order to improve long-term retention. Recommending specific thermostat and refrigerator temperature set-points and monthly HVAC filter changes have been the most effective educational efforts thus far based on customer surveys.

Appendix A. Detailed Statistical Regression Methodology

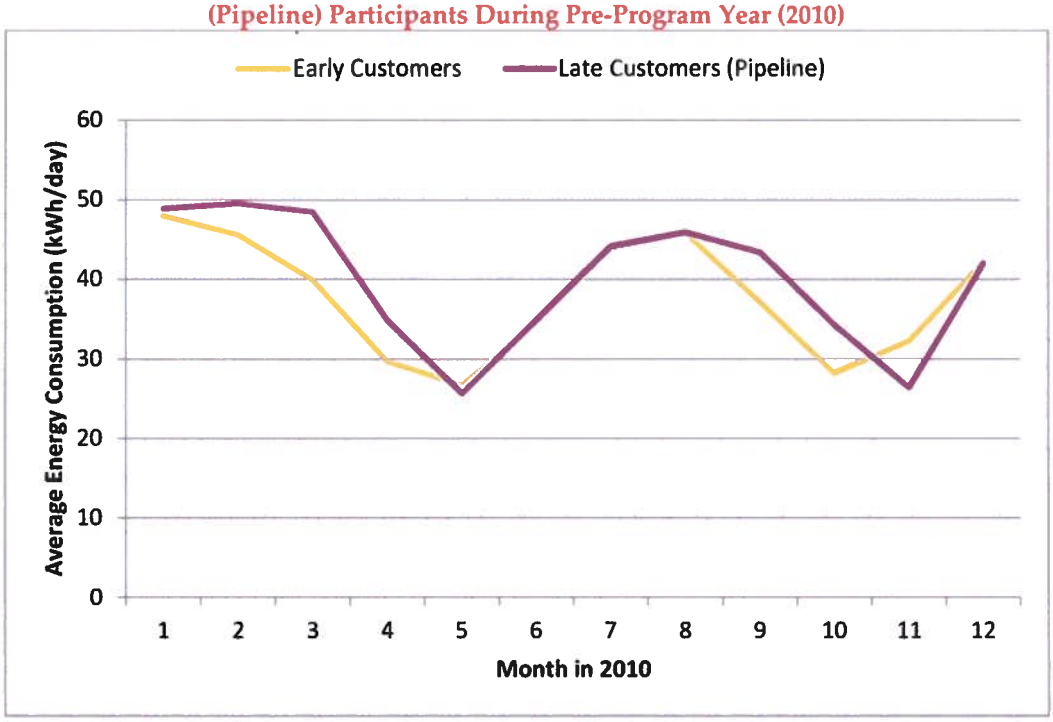
The NES PY2011 billing analysis consists of monthly usage data and program tracking data for participants during PY2011 (January – December 2011) and part of PY2012 (January – June 2012). The billing analysis incorporated usage data for monthly billing cycles ending between November 1, 2008 and June, 30th, 2012. Participants are excluded from the billing analysis if either of the following criteria is met:

- Billing data is unavailable
- Billing errors are present during any of the billing cycles for a given customer
- Customer had less than 12 months of pre-program data and less than two months of post-program data

The billing analysis included 7,070 participants: 4,767 PY2011 participants and 2,303 from PY2012. Given the door-to-door nature of the program and that field crews work consistently throughout the year, enrollment occurs fairly steadily over the course of the year. A "rolling enrollment" of this type provides the opportunity to examine the effect of a program via regression analysis without a separate control group because, except for the first and last months of the study period, each month involves a mix of customers who have already enrolled in the program and those who have not yet enrolled. This also helps reduce selection bias since customers who are in the program necessarily will act similarly to customers who will be in the program at a later date.

Thus, we assume that late participants and early participants are, on average, the same in terms of their energy consumption in the absence of the program. Under this assumption the "late" participants effectively serve as unbiased comparison households for the "early" participants in the regression analysis. As a way to verify the control assumption is valid, Figure A-1 shows a comparison of pre-program monthly energy usage between the PY2011 customers and the PY2012 customers acting as a "pipeline" control group.

Figure A-1.Comparison of Monthly Pre-Install Energy Consumption between Early and Late (Pipeline) Participants During Pre-Program Year (2010)



Source: Navigant Analysis

While the usage between early and late participants is consistent in some months, others are a poorer fit, likely due to geographic differences and regional differences in housing stock. To account for this, the EM&V team specified four seasonal models rather than one annual model. With the fixed effects for each participant in each season accounted for, the seasonal differences in consumption between the early and late adopters are much less significant.

Dataset Preparation/Cleaning

To reduce the influence of outliers in the monthly billing dataset, values more than three standard deviations from the mean daily usage were discarded, removing 1.6% of the data. Also, in order to reduce the uncertainty introduced in the months in which NES customers received the retrofits, the data from the month a customer entered the program was removed from the dataset altogether.

Calculation of Confidence/Precision

Table A-1 below shows the relevant outputs from the billing model as well as the calculation of seasonal variance and the model annual savings estimate. The seasonal variance is simply the product of the square of the standard error and the square of the number of days in the season.

Table A-1. Calculation of Engineering Estimate and Relevant Statistics for Calculating Confidence/Precision

Season	Coeff't of Daily Estimate (β_k)	Std. Error	# of Days	Seasonal Variance	Mean Daily Engineering Estimate (kWh/day)	Seasonal Savings Estimate (kWh)
Winter	-1.4989	0.197	91.25	323.0	1.810	247.54
Spring	-0.6039	0.126	91.25	131.3	1.730	95.37
Summer	-0.1215	0.145	91.25	175.4	1.715	19.02
Fall	-0.2315	0.127	91.25	135.3	1.811	38.26
Total			**365**	**765.0**		**400.2**

Source: Navigant analysis

Note that savings are greatest during the winter season. This is likely because the bulk of savings can be attributed to CFLs and hot water measures, which may be seeing higher savings due to warmer preferred water temperatures and greater number of CFL operating hours during the winter months.

After calculating total variance, relative precision at a particular confidence interval are obtained using the usual methods (Table A-2).

Table A-2. Average Savings Estimate, Confidence Interval, and Precision

Estimated Savings (kWh)	90% CI, Lower	90% CI, Upper	Precision at 90% CI
400.2	354.7	445.7	11.4%

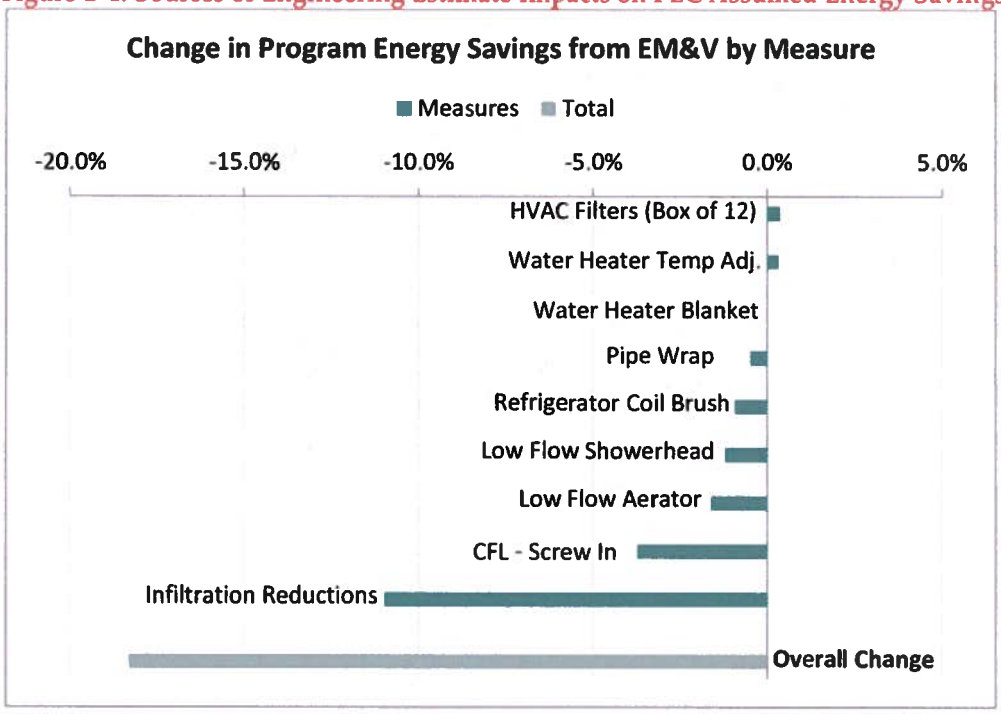
Source: Navigant analysis

Appendix B. Detailed Engineering Methodology

Because the EM&V team used a billing analysis to estimate final program savings, the information provided in this appendix describes only the part of the analysis that provided input to refine the billing model and reduce variability. Savings estimated using engineering methods were not reduced as a result of the lower savings calculated by the billing model, so the numbers presented in this section are only intended to convey relative change in approach and engineering findings from the PY2010 analysis.

Figure B-1 shows the relative change in engineering estimates from PY2010 to PY2011.

Figure B-1. Sources of Engineering Estimate Impacts on PEC Assumed Energy Savings

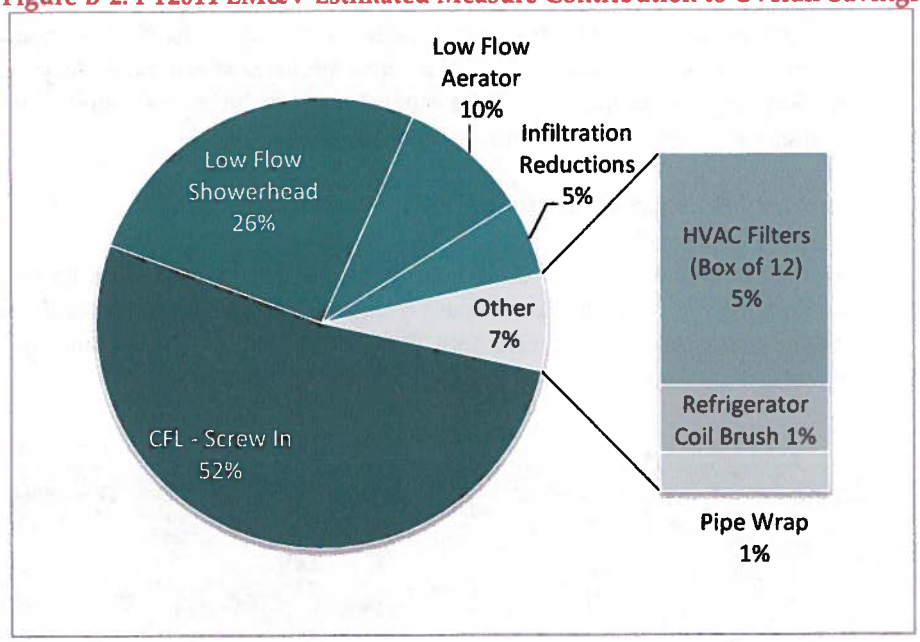


Source: Navigant analysis

The largest contributors to the overall downward change in savings were infiltration reductions, CFLs, and the hot-water conservation measures. The causes for these adjustments are outlined in the measure-by-measure findings and methodology in the sections below.

The relative contribution of each measure to overall program savings shifted significantly as a result of the evaluation effort. Figure B-2 presents a breakdown of the share of total verified savings by measure, and shows that CFLs and low-flow showerheads remain the leading contributors to energy savings, accounting for two-thirds of the savings.

Figure B-2. PY2011 EM&V Estimated Measure Contribution to Overall Savings



B.1 *Winter Peak Savings Estimates*

The EM&V team revised winter peak savings estimates using a process similar to that used for summer peak, with the same 60.4% billing-analysis realization rate applied. The results are shown in Table B-1.

Table B-1. Comparison of Reported to Verified Winter Peak Demand Savings at the Program Level

	[A] Net Savings per Participant (kW)	[B] PY2011 Participation (# of Participants)	[C]=[A]x[B]/1000 Net Savings (MW)
Verified	0.0858	4,908	0.421
PEC Reported	0.176	4,908	0.864
Change in Net Savings			-0.443

Source: PEC tracking database, Navigant analysis

The engineering analysis consisted of three parts:

1. First, the results of the on-site field data collection were used to **derive in-service rates by measure.**
2. Next, **unit savings values were updated** through a review of deemed sources and algorithms, using data collected during the field study to refine algorithms. The team used secondary research to refine savings estimates when appropriate.
3. Finally, the team used verified quantities and updated unit savings values to **calculate measure- and program-level engineering estimates of savings.**

The sections that follow provide more detailed description of the approach used in calculating the engineering estimated savings for each separate measure offered by the NES program, and highlight findings from the field that allowed the EM&V team to refine these estimates. As program-level savings have already been provided in the body of the report based on the billing analysis, only measure-level estimated savings are reported in the summary table for each measure.

B.2 *Compact Fluorescent Bulbs (CFLs)*

Compact fluorescents were verified at a lower level of savings than in PY2010. This is due to a reduction in the unit savings. The verified quantity did not change much from PY2010, but the energy savings adjustment factor was approximately 89%. Table B-2 summarizes a measure realization rate calculation for CFLs, for comparison against PY2010 values.

Table B-2. Engineering Estimate Summary for CFLs (per Participant)

	[A]	[B]	[C] = [B]/[A]
	Assumed Quantity	Verified Quantity	Verification Rate
Quantity	7.24	7.45	102.8%
	Assumed Unit Savings	Verified Unit Savings	Savings Adjustment Factor
Energy (kWh)	51.7	46.3	89.4%
Demand (W)	5.6	5.0	88.6%
	Assumed Per-Participant Savings	Verified Per-Participant Savings	Measure Realization Rate
Energy (kWh)	374.7	344.4	91.9%
Demand (W)	40.9	37.2	91.1%

Source: Navigant analysis, deemed savings documentation

The program tracking database indicates that the NES crews installed a total of 440 CFLs in the 70 homes included in the field study. The EM&V team counted 358 still in use (i.e., 82 bulbs were unverified), yielding an in-service rate of about 81%. This is lower than the PY2010 in-service rate of 92%, largely due to the greater number of CFLs in storage. Out of the 82 bulbs that were not verified as installed, 47 were found in storage. The customer-reported burn-out rate in the sampled homes was approximately 5% (22 out of 440 reported installed). Of those bulbs that burned out, approximately only eight were replaced by the customer with new CFLs while the rest were either still not replaced (at the time of the visit) or had been replaced with incandescent bulbs. Burnouts are accounted for in the in-service rate—energy savings are still awarded in the case where burned-out bulbs were replaced with CFLs. The remaining 13 unverified bulbs were simply unable to be located on-site.

The 102% field verification rate (compared to 2010 quantities) signifies that even with the higher quantities of bulbs in storage, the crews are installing roughly the same numbers as before.

Bulb Size

The first contributor to higher per-unit savings was the actual size, or wattage, of bulbs installed. Figure B-3 shows the breakout of the 358 verified bulbs by size. The majority—roughly two thirds—were 14-watt bulbs. The second most frequently installed were the 20-watt bulbs, followed by 9-watt and 23-watt

bulbs. However, 2011 saw a significant decrease in the number of 20-watt bulbs and a corresponding increase in 9-watt bulbs, effectively lowering the average savings per replacement. Bulb replacements were assumed to be consistent with the "CFL Changeout Watt Equivalent Specifications" table in the NES Scope of Work document, reproduced here in Table B-3.[13]

Figure B-3. Percentage of Verified CFL Quantities by Size

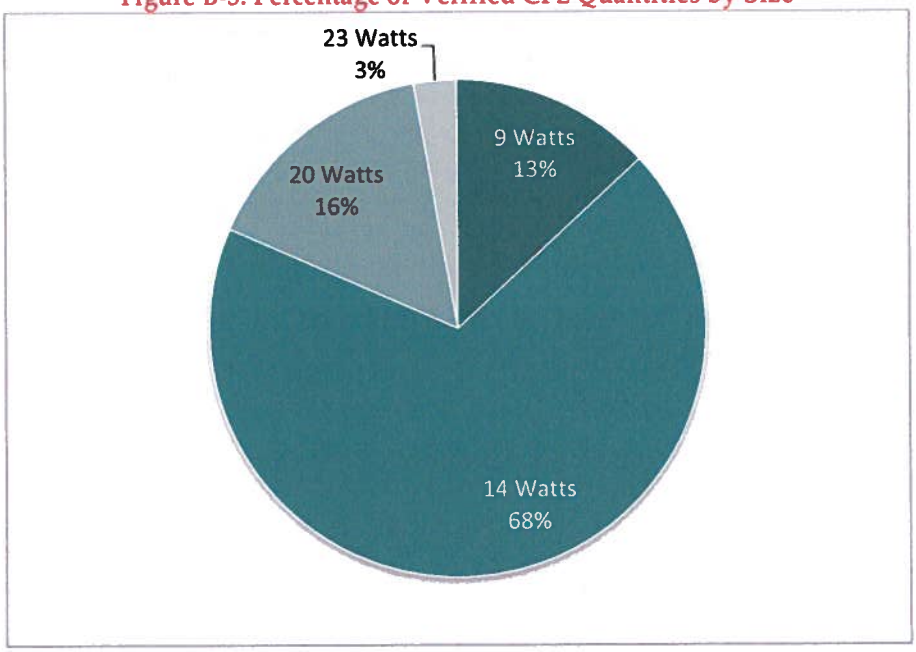


Table B-3. CFL Changeout Watt Equivalent Specifications

Existing Incandescent Wattage	Replacement CFL Wattage (Range)
40 watts	11 watts–13 watts
60 watts	13 watts–16 watts
75 watts	18 watts–20 watts
100 watts	23 watts–25 watts

Source: Work Authorization No. 2, dated July 27, 2009, between PEC and the subcontractor

As there were only four wattages of bulbs installed by the NES crews, they were assumed to match up with incandescent bulbs as follows:

- 9-watt CFLs installed in place of 40-watt incandescents[14]
- 14-watt CFLs installed in place of 60-watt incandescents
- 20-watt CFLs installed in place of 75-watt incandescents
- 23-watt CFLs installed in place of 100-watt incandescents

[13] "Statement of Work for Neighborhood Energy Saver Program" from PEC program documents dated August 13, 2009.

[14] Although Table B-2 above lists 11-13 watts as the replacement value, the EM&V team observed that the installers typically used 9-Watt CFL bulbs to replace the common 40-watt incandescent stove hood lights.

Given the verified mix of CFL sizes and the quantities of each bulb installed, the evaluation team calculated an average power savings of 46.3 watts per bulb, which is about 2 watts lower than PY2010's value of watts saved per bulb.

Bulb Install Location

The second factor contributing to the lower measure realization rate for CFLs is the install location, which affects the operating hours of each CFL. The EM&V team used field verified installation location and then applied the operating hours by occupancy room type from the PEC 2010 Residential CFL Program evaluation. PY2011 saw an increase over PY2010 in the number of bulbs installed in lower-use locations like hallways, bedrooms, and out-of-doors, and a corresponding decrease in the number of bulbs installed in some higher-use areas. The average CFL hours of operation per bulb in PY2011 were estimated to be about 7% lower than in PY2010 because of the change in average install location.

The EM&V team calculated the annual energy savings per bulb using the following equation:

$$kWh\,Saved = \frac{(Watts\,Saved)_{Avg}}{bulb} \frac{Op\,Hrs_{Avg}}{day} \times \frac{365\,days}{yr} \times \frac{kW}{1000\,W}$$

Using the 46.3 average watts saved per bulb and the estimated 2.74 operating hours per bulb per day, the average energy savings per CFL were calculated at 46.3 kWh per year for PY2011, a 10% decrease from PY2010.

B.3 *Refrigerator Coil Brush*

The refrigerator coil brush had a low verification rate of 54%, due to a smaller number of customers that reported having used the coil brush as compared to PY2010. The assumed unit savings were not changed from PY2010.

Table B-4 summarizes EM&V findings for refrigerator coil brushes.

Table B-4. Engineering Estimate Summary for Refrigerator Coil Brushes

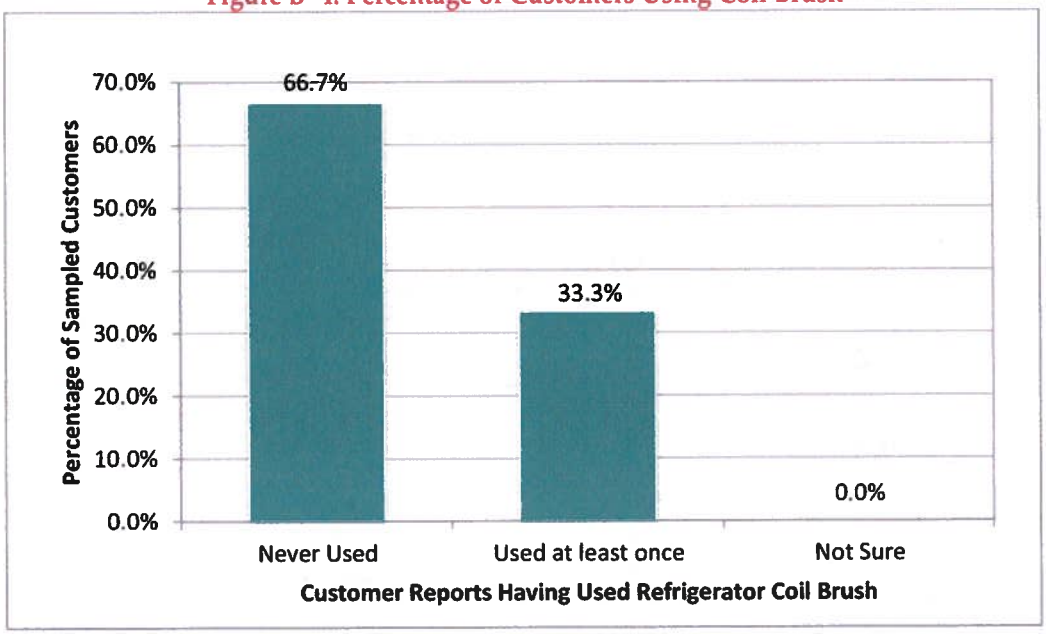
	[A]	[B]	[C] = [B]/[A]
	Assumed Quantity	Verified Quantity	Verification Rate
Quantity	0.38	0.21	54.4%
	Assumed Unit Savings	Verified Unit Savings	Savings Adjustment Factor
Energy (kWh)	43.5	43.5	100.0%
Demand (W)	5.4	5.4	100.0%
	Assumed Per-Participant Savings	Verified Per-Participant Savings	Measure Realization Rate
Energy (kWh)	16.7	9.1	54.4%
Demand (W)	2.1	1.1	54.4%

Source: Navigant analysis, deemed savings documentation

Usage Rates

According to the NES Scope of Work document, every participating home receives a refrigerator coil brush along with instructions and a demo of its use.[15] However, energy savings for this measure are tied to a change in customer behavior. The largest uncertainty in determining the savings attributable to the refrigerator coil brush is its frequency of use. The verification field visit included questions to determine whether the customers still had their coil brush and how often they use it. Figure B- 4 shows the percentage of customers that said they had used the coil brush at least once since they received it.

Figure B- 4. Percentage of Customers Using Coil Brush



Source: Navigant analysis

Given that refrigerator coil brush savings can be realized only when the brush is used by the customer, impacts were based on the actual number of customers maintaining their refrigerator coils at least once a year. Thus, as only 10 of the 48 sampled participants reported using the coil brush at least once every three months (the threshold assumed to yield energy savings), the EM&V team recorded 21% as the in-service rate. This, combined with the energy savings adjustment, gave a net energy realization rate of 54.4% as compared to PY2010.

B.4 Low-Flow Shower Head

Engineering estimates for savings from low-flow showerheads were 5% lower than those from PY2010. Although the unit savings were 20% lower due to cold water temperatures being warmer on average than previously assumed, there were more units were installed, which countered the low unit savings.

[15] "Statement of Work for Neighborhood Energy Saver Program" from PEC program documents dated August 13, 2009.

One of the drivers of hot water savings measures is the cold water inlet (mains) temperature. The colder the inlet temperature, the greater the energy required to heat the water each time it is used. This makes savings for hot water dependent on regional mains temperatures. In contrast to the PY2010 analysis, inlet temperatures for this year's analysis were based on actual measured temperatures, adjusted for seasonal variation. Since measured temperatures were warmer on average than the literature-cited values used in PY2010, unit savings were about 20% lower in PY2011. Otherwise, the savings algorithms used are the same as those used during the PY2010 evaluation.

Approximately 4% of customers chose to replace their showerheads after the NES crews left as a matter of preference. However, flow rates on the replacement showerheads were still considered low-flow (less than two gallons per minute), so no change was made to the in-service rate for these homes.

Table B-5 summarizes the results of the engineering analysis for low-flow showerheads. With savings adjustment factor of 80% for energy the 19% higher verified quantity over PY2010, the final measure realization rate was approximately 95%.

Table B-5. Engineering Estimate Summary for Low-Flow Showerheads

	[A]	[B]	[C] = [B]/[A]
	Assumed Quantity	Verified Quantity	Verification Rate
Quantity	0.76	0.90	118.7%
	Assumed Unit Savings	Verified Unit Savings	Savings Adjustment Factor
Energy (kWh)	239.9	191.1	79.7%
Demand (W)	17.1	14.8	86.4%
	Assumed Per-Participant Savings	Verified Per-Participant Savings	Measure Realization Rate
Energy (kWh)	181.5	171.7	94.6%
Demand (W)	12.9	13.3	102.6%

Source: Navigant analysis, deemed savings documentation

B.5 Low-Flow Faucet Aerator

As with low-flow showerheads, the EM&V team verified savings for low-flow faucet aerators based on an engineering algorithm involving cold water inlet temperature, so the verified unit savings were somewhat lower than in PY2010. Otherwise, the savings algorithms did not change from PY2010.

Table B- 6 summarizes engineering estimates for this measure. Verified quantities were higher than in PY2010 by about 6%.

Table B-6. Engineering Estimate Summary for Low-Flow Faucet Aerators

	[A]	[B]	[C] = [B]/[A]
	Assumed Quantity	Verified Quantity	Verification Rate
Quantity	1.48	1.57	105.9%
	Assumed Unit Savings	Verified Unit Savings	Savings Adjustment Factor
Energy (kWh)	51.0	39.7	77.9%
Demand (W)	6.4	4.9	76.7%
	Assumed Per-Participant Savings	Verified Per-Participant Savings	Measure Realization Rate
Energy (kWh)	75.5	62.4	82.6%
Demand (W)	9.4	7.6	81.2%

Source: Navigant analysis, deemed savings documentation

B.6 HVAC Filter Replacement

According to the PY2011 tracking database, homes participating in the program received an average of 9.6 filters out of the total of 12 possible filters (roughly equivalent to 80% of the homes having received all 12 filters). Some homes did not receive any filters because they did not have central air. Other homes received only one or two filters either for window AC units or as custom-cut fiber filters for off-sized central air HVAC systems. The EM&V team focused on calculating the fan energy savings from decreased filter pressure drop for homes which received more than two filters, corresponding in most cases to homes with central air.

Energy savings algorithms were revised to estimate fan energy savings based on the approximate pressure drop caused by reducing the time between filter changes. The algorithm is shown below:

$$Ann.\ kWh\ savings = \frac{(Air\ flow\ in\ CFM) \times (PD_{90} - PD_x) \times (Operating\ Hours)}{(fan\ efficiency) \times (8515)}$$

where:

- PD_{90} = Pressure drop at the filter at 90 days (inches H_20)
- PD_x = Pressure drop at the filter at x days (inches H_20), specific to each participant in the sample that reported changing filters more frequently than 90 days.

Table B-7 shows the end results of the analysis.

Table B-7. Engineering Estimate Summary for HVAC Filter Replacement

	[A]	[B]	[C] = [B]/[A]
	Assumed Quantity	Verified Quantity	Verification Rate
Quantity	0.44	0.39	89.2%
	Assumed Unit Savings	Verified Unit Savings	Savings Adjustment Factor
Energy (kWh)	64.5	79.7	123.5%
Demand (W)	15.3	19.0	123.5%
	Assumed Per-Participant Savings	Verified Per-Participant Savings	Measure Realization Rate
Energy (kWh)	28.5	31.4	110.1%
Demand (W)	6.8	7.5	110.1%

Source: Navigant analysis, deemed savings documentation

B.7 *Infiltration Reductions*

Overall, the NES installation crews did a thorough job installing the various infiltration reductions items (caulk, door sweep, foam spray, weather stripping, and AC weatherization kits). On a scale of 1 to 5, the infiltration reductions measure had a 4.5 installation quality on average. The EM&V team translated this into a 1.0 in-service rate, meaning that the quantities reported in the database are generally found to be in good standing in the field. However, the primary uncertainty for this measure is whether the typical level of effort per house is great enough to reach the 15% infiltration reductions claimed in the deemed savings sources (referencing line item 360 in the North Carolina Measures Database).[16] In order to accurately determine savings attributable to the infiltration reductions measures, a pre-post blower-door study would be necessary, though the estimated savings may be too small to warrant such a study.

In order to more accurately estimate savings, the EM&V team revisited the NC measures database savings assumptions from PY2010. Rather than assuming 15% infiltration reductions for a typical home that received infiltrations measures, the EM&V team chose to scale savings linearly based on the quantity of measures installed (as recorded in the tracking database), also taking into account the geographic location and housing configuration on variability in savings. The NC measures database lists a number of different savings estimates for infiltration reductions based on energy simulation models, each line-item varying by level of effort (10% or 15% reductions in infiltration), climate, housing type, and vintage. Using data collected during the field visits, homes were assigned a specific line-item for savings. Homes receiving 1-3 measures were assigned 5% savings. Those receiving 4-7 measures were assigned 10% savings, while those receiving > 7 measures were assigned 15% savings.

This new estimate of unit savings of 44.4 kWh per home (that receives infiltration reductions measures) is significantly lower than PY2010, but it is likely closer to the mark, given the low billing estimates for per-home savings. Table B-8 summarizes the energy and peak demand savings for this program.

[16] NC Measures Database - Master file of Results 8-27-08 with weighting tool.

Table B-8. Engineering Estimate Summary for Infiltration Reductions

	[A]	[B]	[C] = [B]/[A]
	Assumed Quantity	Verified Quantity	Verification Rate
Quantity	0.76	0.80	105.1%
	Assumed Unit Savings	Verified Unit Savings	Savings Adjustment Factor
Energy (kWh)	164.0	44.4	27.1%
Demand (W)	59.7	24.6	41.2%
	Assumed Per-Participant Savings	Verified Per-Participant Savings	Measure Realization Rate
Energy (kWh)	124.2	35.3	28.4%
Demand (W)	45.2	19.5	43.3%

Source: Navigant analysis, deemed savings documentation

B.8 Water Heater Temperature Adjustment

Although water heater adjustments are not tracked in the database, the EM&V team used the installation invoices provided by the implementation contractor to determine how often temperature adjustments actually take place. According to NES program documentation, the threshold for water heater temperature adjustments is 135°F, while the target temperature after adjustment is 120°F.[17] Out of the 48 homes visited, two had water heater adjustments according to the installation invoices. The EM&V team used the measured cold-water temperatures and water heater size to estimate unit savings according to standard heat loss algorithms for water heaters.[18] Table B-9 shows the engineering estimates of savings.

Table B-9. Engineering Estimate Summary for Water Heater Temperature Adjustment

	[A]	[B]	[C] = [B]/[A]
	Assumed Quantity	Verified Quantity	Verification Rate
Quantity	0.00	0.04	n/a
	Assumed Unit Savings	Verified Unit Savings	Savings Adjustment Factor
Energy (kWh)	40.0	61.7	154.3%
Demand (W)	2.9	7.0	240.2%
	Assumed Per-Participant Savings	Verified Per-Participant Savings	Measure Realization Rate
Energy (kWh)	0.0	2.6	n/a
Demand (W)	0.0	0.3	n/a

Source: Navigant analysis, deemed savings documentation

[17] "Statement of Work for Neighborhood Energy Saver Program" from PEC program documents dated August 13, 2009.

[18] "Engineering Methods for Estimating the Impacts of Demand-Side Management Programs: Volume 2." Architectural Energy Corporation/ Hagler, Bailly, Inc., Boulder, CO. Section 3 page 160

B.9 Water Heater Pipe Wrap

The EM&V team kept unit savings for this measure the same as in PY2010. The database reported quantity was lower this year, and the in-service verification rate was only 80%, due to pipe wrap being installed on non-electric water heaters in some cases. Table B-10 summarizes savings for this measure.

Table B-10. Engineering Estimate Summary for Water Heater Pipe Wrap

	[A]	[B]	[C] = [B]/[A]
	Assumed Quantity	Verified Quantity	Verification Rate
Quantity	0.40	0.23	57.0%
	Assumed Unit Savings	Verified Unit Savings	Savings Adjustment Factor
Energy (kWh)	23.1	23.1	100.0%
Demand (W)	2.6	2.6	100.0%
	Assumed Per-Participant Savings	Verified Per-Participant Savings	Measure Realization Rate
Energy (kWh)	9.2	5.3	57.0%
Demand (W)	1.1	0.6	57.0%

Source: Navigant analysis, deemed savings documentation

B.10 Water Heater Blanket

Impacts from water heater blankets during PY2011 were nonexistent. Of the seven water heater blankets recorded in the database, the EM&V team visited three of the sites but found no water heater blankets in place. It is assumed that the discrepancy was due to clerical error, so no savings were assigned for this measure. Since the PY2010 report recommended installing more water heater blankets when possible, the EM&V team conducted a preliminary review of the unit savings. Assuming a 40 gallon water heater size and standard characteristics for a modern water heater, savings were estimated at 153.4 kWh per water heater using standard heat-loss equations.[19] However, savings estimates in future work will necessarily be based on actual installed characteristics of the water heaters. Table B-11 summarizes findings for water heater blankets.

[19] Ibid. section 3 page 154

Table B-11. Engineering Estimate Summary for Water Heater Blanket

	[A]	[B]	[C] = [B]/[A]
	Assumed Quantity	Verified Quantity	Verification Rate
Quantity	0.00	0.00	n/a
	Assumed Unit Savings	Verified Unit Savings	Savings Adjustment Factor
Energy (kWh)	315.0	153.4	48.7%
Demand (W)	23.1	17.5	75.8%
	Assumed Per-Participant Savings	Verified Per-Participant Savings	Measure Realization Rate
Energy (kWh)	0.0	0.0	n/a
Demand (W)	0.0	0.0	n/a

Source: Navigant analysis, deemed savings documentation

Appendix C. Statistical Significance of Engineering Estimates

C.1 *Sampling Error as Described by Confidence and Precision*

Sampling precision for the field verification work to feed the engineering estimates was determined for each sample stratum's average realization rate using a 90% confidence interval. The analysis was conducted using the variation in overall household energy savings based on multiplying per-measure deemed energy savings values by database recorded quantities for sampled homes. Precision values were calculated using stratified ratio estimation, with the key parameter being the average stratum realization rate (i.e., the ratio between estimated savings for homes in a given region and housing type and the standard reported savings of 810 kWh).[20] The difference between each estimated per-participant savings value and the per-home predicted value of 810 kWh was then the basis for determining a variance for the stratum that was used for purposes of statistical precision calculations.

The overall confidence and precision of the energy verification rates is 90/9.3, indicating a 9.3% relative precision at a 90% confidence interval. Results for individual strata are generally less precise, but the overall program verification rate has relatively low uncertainty and signifies that sampling error for the engineering estimates is not an issue. Table C-1 summarizes the results.

[20] The evaluation team stratified the sample by region and housing type. Ratio estimation refers to the method of assessing the statistical significance of reported savings. Rather than merely analyzing the verified savings values for each project in the sample, the evaluation analyzed the ratio of verified savings to reported savings, which generally reduces the variability of data across sampled sites, and thus lowers the coefficient of variation.

Table C-1. Uncertainty in Average Realization Rate EM&V Field Verification Sample

Region	Building Type[a]	Population	Sample	Confidence/ Precision
Eastern	Manufactured Housing	10	2	90/230
Eastern	Multi-Family	649	4	90/72
Eastern	Single Family	1418	14	90/17
Southern	Manufactured Housing	340	4	90/43
Southern	Multi-Family	555	4	90/8
Southern	Single Family	1118	9	90/32
Western	Manufactured Housing	518	5	90/6
Western	Multi-Family	173	1[a]	N/A[a]
Western	Single Family	123	5	90/31
	Overall Total:	**4904[b]**	**48**	**90/9.3[c]**

[a] Two multi-family homes were targeted in the western region, but only one was completed successfully. This stratum was ignored during the final c/p calculation.
[b] There were only 4 homes in the northern region, which did not warrant sampling in that region.
[c] Overall precision at the confidence interval is *better* than the average of the precision of various strata, because grouping like elements into strata decreases the variability, which improves precision overall.
Source: Navigant analysis

Appendix D. Process Findings

The evaluation team conducted 48 on-site visits for the purposes of verifying measures installed and interviewing participants about:

- their satisfaction with the program,
- their awareness of the program measures before the NES provided them,
- the impacts the program has had on their own energy efficiency practices and habits, and
- the extent to which the program influenced any subsequent energy efficiency purchase decisions they may have made.

Participants were also asked about their intentions and plans to purchase any of the program measures if the program had not provided them, as well as their actual purchases since the program installations. The EM&V team completed 48 interviews were. All interviewed customers conveyed their satisfaction with the NES program in some manner, including appreciation for the perceived financial relief it brings on their electric bill. Some customers had specific suggestions for improving the program in the future. The pertinent field notes from these customer interviews appear below (numbers in parentheses refer to the number of customers making similar requests):

- Customer would like more CFLs
- Customer would like other sizes of CFLs (small base, etc) (x3)
- Rubber part of door sweep sometimes slides out of its track (x2)
- Customer would like to see more in-depth air sealing, large appliance retrofits, window replacements, etc. (x2)
- Customer would have liked a better kitchen quality faucet aerator—theirs broke
- Customer says the crew ran out of HVAC filters and forgot to come back to give them a box later

D.1 Survey Results

Table D-1 shows the number of participants that were aware of the different efficiency measures before the program. Participants were particularly aware of CFLs (87%), while awareness of other measures generally ranged from about one-third to two-thirds of respondents. Awareness of refrigerator brushes was lowest, at 26% of respondents.

Table D-1. Customers Aware of Measures Before NES

Measure	Aware	Percentage
CFLs	41	87%
Showerhead	25	53%
Aerator	15	32%
Coil Brush	12	26%
Pipe Insulation	36	77%
Filter Change	41	87%
Reduce infiltration	35	74%

Source: Navigant analysis

In general, customers reported that they would not have purchased or installed most of the energy efficiency measures absent the program. Only for CFLs did more than 10% of respondents claim an intention to purchase/install (Table D-2).

Table D-2. Would Have Purchased Measures in Absence of NES

	CFLs	Shower-head	Faucet Aerator	Coil Brush	Pipe Insulation	Filter change	Infilt. meas.
Would have purchased	22	4	1	1	1	3	1
Would not have purchased	25	43	46	46	46	44	46
Don't Know	1	1	1	1	1	1	1
No Response	0	0	0	0	0	0	0
Total	**48**	**48**	**48**	**48**	**48**	**48**	**48**
Percent would have purchased	**46%**	**8%**	**2%**	**2%**	**2%**	**6%**	**2%**

Source: Navigant analysis

Customers frequently had a difficult time recalling any specific actions the NES crews recommended in order to reduce energy use. Table D-3 shows the percentage of customers who could or could not recall any recommendations. Of the 13 customers who recalled one of the actions recommended by the NES crews, 10 said they actually made changes in their behavior because of the program.

Table D-3. Customers Recalled Specific Actions

	Quantity	Percentage
Yes	13	27%
No	33	69%
Customer not present during install	2	4%
Total	**48**	**100%**

Source: Navigant analysis

D.2 Net-to-Gross Ratio

Savings attributable to efficiency programs are often adjusted for free ridership and spillover/market effects. A formal assessment of free ridership and spillover was not conducted during this analysis, although participant responses to several survey questions support a NTG ratio of 1.0. Survey participants were asked if they would have purchased any of the measures if the NES program were not available to them. For most measures, very few or no respondents said they would have purchased the measures anyway. The CFL measure was the sole outlier. Although 48% of respondents said they would have purchased CFLs in the absence of NES, studies have shown that low-income and rental households purchase CFLs at a much lower rate than general residential customers.[21] Furthermore, as a direct install program, NES only installs measures that are not already in the home. If customers had already installed any program measures, the program database would capture this via a smaller number of recorded program installations. Furthermore, the billing analysis takes yields net savings, so the NTG ratio is already included in the EM&V verified savings described in the body of this report.

D.3 Field Data Collection Forms

The following two pages show the field data collection forms used in conducting the field work for this program.

[21] Mills, Bradford and Schleich, Joachim. "Why Don't Households See the Light?: Explaining the Diffusion of Compact Fluorescent Lamps." Working Paper No. 2008-09. Virginia Polytechnic Institute and State University, Blacksburg, VA. 2008.

NAVIGANT

2012 PEC Neighborhood Energy Saver — A. Site Information & Scheduling

Site ID:		Home Type:		Customer Name:	
Customer Address:				City:	
State		Zip:		Region	
Phone Number		Alt. Phone		NES Install Date:	
Scheduling Notes:					

B. Site Characteristics and General Survey

Arrival Date				Home Ownership:	Rent	Own	Other
Total Square Footage of Home:				Total Conditioned Floorspace:			
Year Built:				Number of Stories:			
Number of Units in Building (if MF):				Number of walls exposed to exterior (if MF):			
Dominant Cooling Type (Circle one):	A/C (split)	AC (packaged)	A/C (window)	None	Other:______________		
Dominant Heating Type (Circle one):	Furnace	Electric Resistance	Electric Heat Pump	None	Other:______________		
Survey Questions - *Only complete if customer was living in the home on the date the NES installation occurred.*							
Had you heard of all of of these energy efficiency items before the NES installation crews came by?					Yes	No	Don't Know
If some are new to you, which ones?	CFL	LFSH	LFFA	RCB	WHPI	HVACF	IR
Had you been planning to purchase any of the energy efficient items before the crews came by?					Yes	No	Don't Know
If yes, which ones?	CFL	LFSH	LFFA	RCB	WHPI	HVACF	IR
Have you purchased any new energy efficient items since the NES crews came through?					Yes	No	Don't Know
If yes, please describe:							
Do you think you would have done any of these things if the program did not exist?					Yes	No	Don't Know
If yes, which ones?	CFL	LFSH	LFFA	RCB	WHPI	HVACF	IR
Please describe:							
Other than the items the NES crew installed, can you recall any specific actions they recommended for lowering your energy use? Please describe:							
If yes, did you do any of these things on your own after the NES crew left? Please Describe:							
Gift Card Number:							
Gift Card Delivery Date:				Gift Card Delivery Method:	Mail	In Person	See Notes
Additional Notes about Residence:							

C. Lighting (CFLs)

Index	Measure Subcategory	Database Reported Measure Qty
1	CFL - Screw In 09 W	
2	CFL - Screw In 14 W	
3	CFL - Screw In 20 W	
4	CFL - Screw In 23 W	

Field Verified Quantities

Qty	Space Type - circle one	CFL Size (W) - circle one
	hall bath kitchen bed living utility outside dining other____	9 14 20 23 other____
	hall bath kitchen bed living utility outside dining other____	9 14 20 23 other____
	hall bath kitchen bed living utility outside dining other____	9 14 20 23 other____
	hall bath kitchen bed living utility outside dining other____	9 14 20 23 other____
	hall bath kitchen bed living utility outside dining other____	9 14 20 23 other____
	hall bath kitchen bed living utility outside dining other____	9 14 20 23 other____
	hall bath kitchen bed living utility outside dining other____	9 14 20 23 other____
	hall bath kitchen bed living utility outside dining other____	9 14 20 23 other____
CFL Notes:		
# CFL burnouts______	# burnouts replaced with CFLs______	# burnouts replaced with incandescent:______

D. HVAC Filters

Filter Level of Soiling:	1 = very clean 5 = very dirty (circle one):	1 2 3 4 5 Don't Know	
Database Reported Qty Delivered:		Unused (Fresh) Filters:	
Filter Change Frequency (Wks):		HVAC Filter Notes:	

E. Refrigerator Coil Brush

Database reports customer received coil brush:		If No, skip this section.	
Customer still has coil brush:	Yes No Don't Know	Coil easily accessible:	Yes No Don't Know
Coil's level of soiling	1 = very clean 5 = very dirty (circle one):	1 2 3 4 5	Don't Know
I use the coil brush...:		months	
Coil location:		Back Bottom Don't Know	
Coil Brush Notes:			

F. Low Flow Showerheads, Faucet Aerators & Water Heater Temperature Adjustment

# of low-flow showerheads installed:		Quantity verified:	
Flow test performed?	Yes No	Water flow (sec per Quart)	
Did customer replace any showerheads?	Yes No Don't Know	If yes, why?	
# of low-flow faucet aerators installed		Quantity verified:	
Flow test performed?	Yes No	Water flow (sec per Quart)	
Did customer replace any faucet aerators?	Yes No Don't Know	If yes, why?	
Did the NES crew adjust the hot water temperature?		Yes No Don't Know	
Initial set temperature from form (deg F):		Current hot temperature (Deg F):	
Did customer adjust the temperature?	Yes No Don't Know	Current cold water temp (Deg F):	
Is main water heater electric?	Yes No Don't Know	Conditions where water heater is:	Conditioned Uncond. Don't Know
Water Heater Mfg/Model (electric only)		Accessible for wrap?	Yes No Don't Know
Hot water efficiency measure notes:			

G. Fenestration and Pipe Insulation

		Verification of Database Reported Quantities								
Measure Subcategory	Qty	Verified			Quality/condition (1=poor 5=excellent)					Notes
Caulk		Yes	No	DK	1	2	3	4	5	
Door Sweep		Yes	No	DK	1	2	3	4	5	
Foam Spray		Yes	No	DK	1	2	3	4	5	
Glass Patch Tape		Yes	No	DK	1	2	3	4	5	
Pipe Wrap		Yes	No	DK	1	2	3	4	5	
Water Heater Wrap		Yes	No	DK	1	2	3	4	5	
Weather Strip		Yes	No	DK	1	2	3	4	5	
Winterization Kit		Yes	No	DK	1	2	3	4	5	

H. Wrap-Up Checklist

Gave gift card or made arrangements to mail	☐
Replaced all HVAC panels/covers	☐
Collected all tools and equipment	☐
Thoroughly Completed sections B-G above	☐